Space Weather Technical Forecast

Issued on Sunday, 07 May 2023 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1-R2 Radio Blackouts throughout. Low confidence CME arrivals day 1 (07 May) bring a likelihood of G1-G2 Minor/Moderate storms, with a chance of G3/Strong Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with the largest flare peaking at C4.7 at 06/2157UTC from AR3299. There are a trio of spot groups spanning the northeast to north-centre disc, namely AR3293, AR3296 and AR3297. AR3296 is the most interesting as an anti-Hale cycle region (reverse polarity) although this region has declined a little. Some small growth and development of small spots has been seen around the other the other two regions, resulting in increased complexity, however these currently remain stable. There are three further small and magnetically simple spots, including the source of the C-flare AR3299. Multiple CMEs were observed on the 06 May, however analysis shows no Earth directed components.

Solar Wind / Geomagnetic Activity: The solar wind showed the waning influence of a CME and declining connection to CH99 fast wind. Observed speeds at L1 declined from elevated at around 500-550km/s to be slightly elevated at 400-450km/s. Density was largely above average at first but soon declined to be below average until 07/0725 UTC. A climbing trend has then been observed, reaching above average values of 15-20ppcc. Total IMF strength, Bt, was initially Moderate, peaking 11nT, before easing to Background at 3-6nT from 06/2200 UTC. The north-south, Bz, component was variable between -5nT and +8nT. Phi angle was mainly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled with an isolated Active interval (Kp2-4) 06/1200-06/1500 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has been at background levels throughout. High energy electron flux (greater than 2MeV) as measured at GOES16, was also at background levels. The 24-hour integrated fluence was at Active levels, but dropped below by 06/1800UTC. At 07/0000 UTC 7.71e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: A chance of Moderate activity is expected through the next four days, mainly from the regions in the northeast to north-centre disc.

Solar Wind / Geomagnetic Activity: Two CMEs which left the Sun on 04 and 05 May respectively, are forecast to arrive on day 1 (07 May), perhaps concurrently, with a risk of effects into 08 May. Confidence is low with their speeds, and how much material will be within them, giving a low confidence to the geomagnetic forecast. Otherwise current slightly elevated solar winds are expected to gradually ease through the period, once any CME influence has passed. Generally Quiet to Unsettled conditions are expected at first day 1 (07 May). Any CME arrivals are likely to bring a spell of G1-G2 Minor to Moderate storms, with a chance of G3 Strong storms. This risk recedes later day 2 (08 May) with activity becoming mainly Quiet to Unsettled.

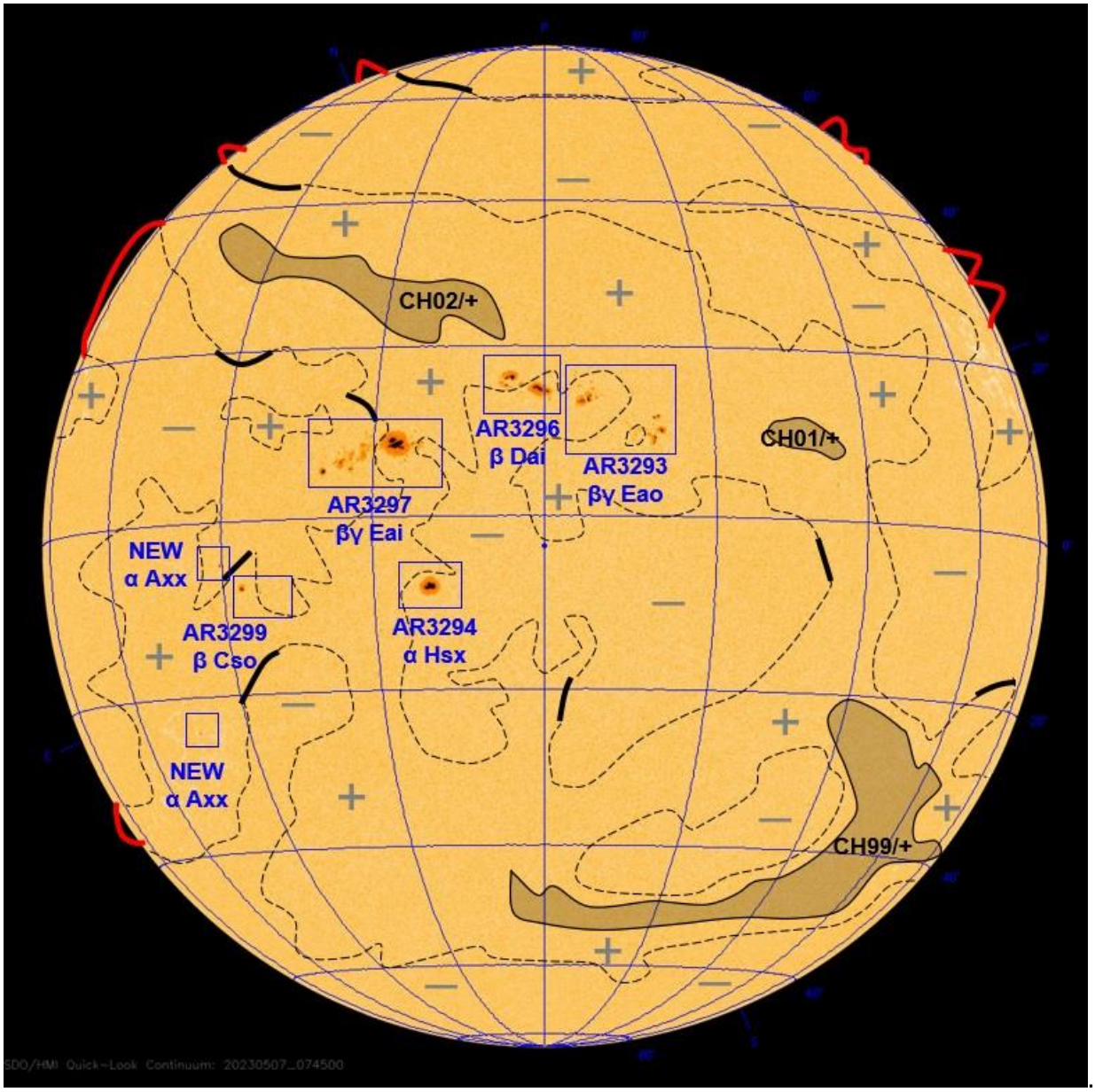
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to persist at background with no solar radiation storms occurring. High energy

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

(greater than 2MeV) electron flux is expected to persist at background levels, perhaps rising to Moderate, potentially High later day 3 or day 4 (09 or 10 May). The associated 24 hour fluence is forecast to persist below the Active threshold.

Figure 1. Solar Analysis Valid 07/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

Two CMEs are likely to arrive on day 1 (07 May) with ongoing effects into day 2 (08 May). The first is associated with an M3.9 flare from AR3296 on 04 May. This was a complex eruption with the main ejecta to the east, behind Earth, but also a full halo shock observed. The second CME is another complex eruption that likely originates from an M2.1 flare of AR3296 early on 05 May. This occurred very soon after a C9-flare from AR3297, and is complicated further by a nearby limb E-limb CME that occurred previously. This also has an eastward ejecta component visible, and a clear Earth-directed halo shock.

These CMEs are likely to arrive day 1, perhaps early day 2 (07 and 08 May) with ongoing influence continuing day 2. There are a number of sources of uncertainty. This includes the potential for these to arrive together as a single CME, but also for very little impact to occur if only shock is observed, rather than any ejected plasma. However, current ACE EPAM data is suggestive of an approaching CME, with the low energy proton count rising, increasing confidence for at least one arrival later day 1.

Otherwise, any influence from the HSS of CH99 is expected to gradually ease away, with winds easing to background day 3 and day 4 (09 and 10 May) as any CME enhancement subsides.

Initially Quiet to Unsettled conditions are likely to rise to give G1-G2 Minor to Moderate storms later day 1 and into day 2 (07 and 08 May), with a chance of reaching G3 Moderate storms, This most likely if the two CMEs arrive in close proximity or combine into a single arrival. Any CME influence is expected to then ease away later day 2 and into day 3 (08-09 May) with mainly Quiet conditions, with isolated Unsettled intervals following.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	70	10	1
Strong	G3	No	25	20	1	1
Severe	G4	No	2	2	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1440	Full	AR3296 M3.9	NE	720	07 May PM	Low confidence.
05/1117	Full	AR3296 M2 or AR3297 C9	NE	950	07 May PM/08 May AM	Low confidence

Figure 2.1: Enlil and Ensemble

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

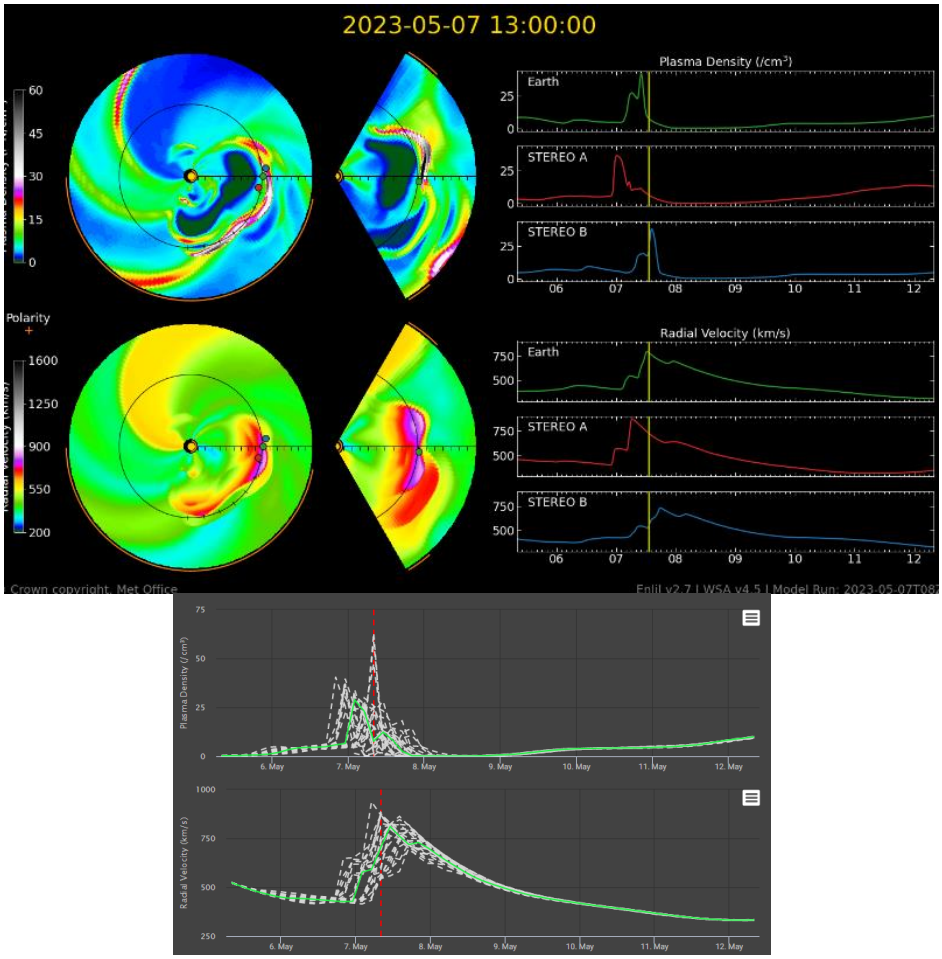
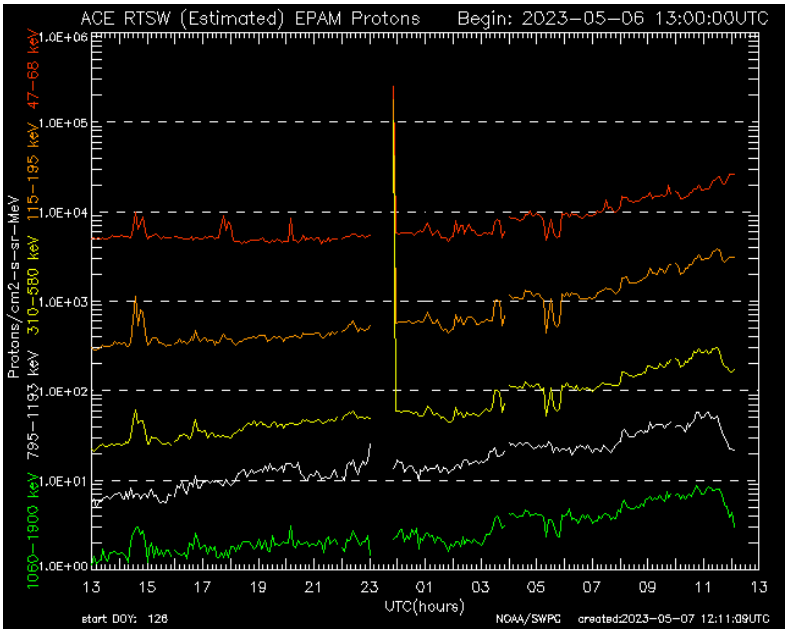


Figure 2.2: ACE EPAM low energy protons with rising trend – suggest incoming CME.
*



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

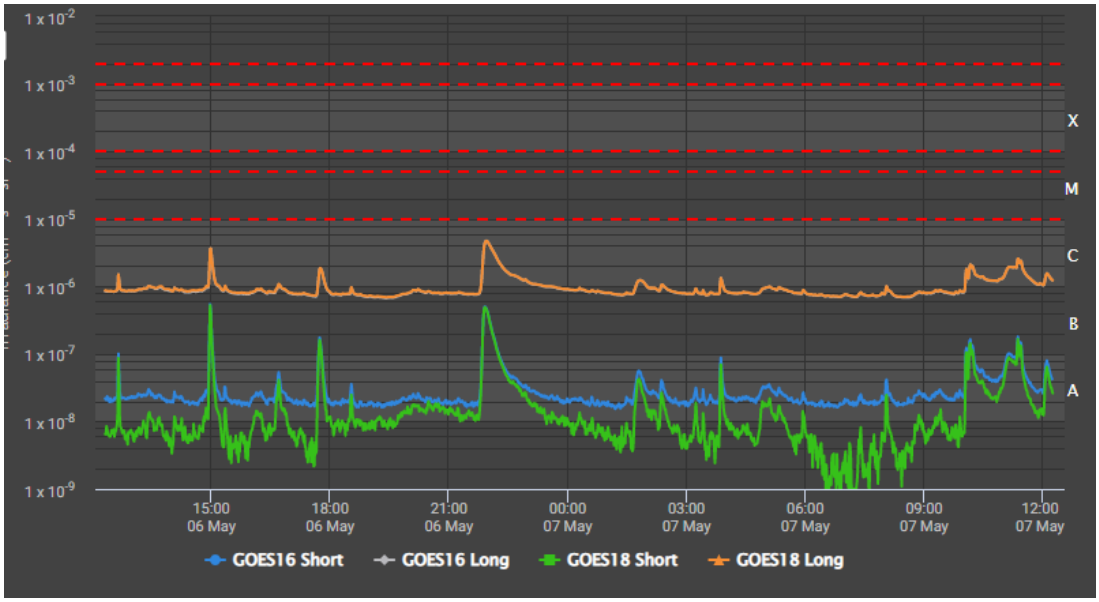
Radio Blackouts - X-Ray Flares:

Low to Moderate activity is expected to continue, with an ongoing chance of isolated M-flares.

These are most likely from the three magnetically interconnected sunspot regions across the northern disc. These sunspots have been on a maturing trend, with little recent activity, however some slight growth and complexification has been observed in both AR3293 and AR3297 due to the emergence of reverse polarity flux near their leaders that may lead to destabalisation. AR3296, which is the central region, has exhibited a slight decline. Despite this, as an anti-Hale cycle region (with reverse polarity to northern hemisphere expectations given for SC25) and with a history of M-flaring, this also has the potential for notable flares. There are four other smaller and simple regions, giving a total of seven on the disc, however these are currently considered less likely to produce significant flaring.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	55	55	55	55
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16/18 X-ray Flux



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

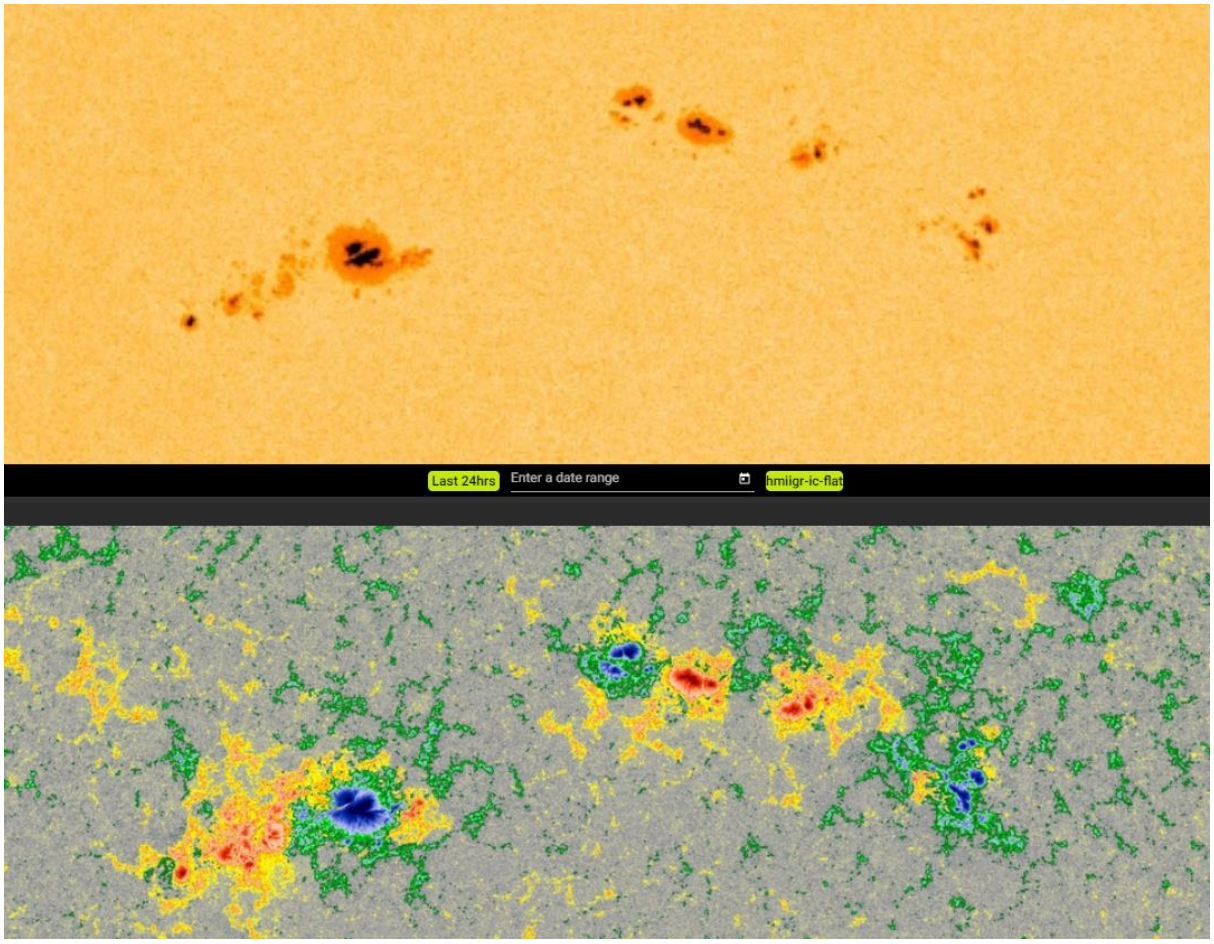
© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux as observed by GOES-16 is expected to persist at background levels. However, there is a slight chance that count rates may increase with the potential for Moderate flares from the three main sunspot regions across the northern solar disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO intensitygram and Magnetogram of northern disc, show main sunspots of interest



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

The electron forecast is of particularly low confidence, especially beyond day 1 (07 May) as it will be dependent upon the arrival of CMEs, which have a large amount of uncertainty on them.

High energy electron flux (greater than 2MeV) observed by GOES- is at background, and is expected to largely persist at this level through day 1 and 2 (07-08 May) due to the likelihood of further CME arrivals. As the geospace environment eases on day 3 and into day 4 (09-10 May), electron count rates at GEO have the potential to rise again. This may allow diurnal peak to reach Moderate levels, with a chance of reaching High.

The associated 24 hour fluence dropped below the active level by 06/1800 UTC and is expected to persist at this level during days 1 and 2, with only a chance of rising again by the end of day 4 (09 May). REFM is likely to be unreliable in the forecast period due to arrival of CMEs.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	1	5	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 Electron Flux and Fluence with REFM

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.